MULTISPECTRAL HIGH FIDELITY RADAR SCENE GENERATOR

PROGRAM PROGRESS REPORT

SBIR PHASE I; TOPIC N99-059

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This is the first monthly progress report for the Miltispectral High Fidelity RADAR Scene Generator SBIR (Phase I), Contract # N68335-99-C-0126.

1.0 Work Summary

The work done between Feb.12 and Mar.12 centered around sizing the computer resources required to efficiently perform the RADAR Scene Generator (RSG) mission. The focus of the effort centered around the memory size required to simulate the RADAR environment as a function of the RADAR parameters. This effort required examination of the detailed steps of some of the key processes.

2.0 Schedule

As indicated in the proposal, the goal for the first month was to size the computer resources required as a function of the RADAR parameters, and that has been accomplished. The program is on schedule.

3.0 Studies

A hypothetical RADAR was considered, and computer memory was sized for it. A spreadsheet was used to calculate the memory size as a function of various parameters. The assumptions and the resulting outcome has been presented below:

The RADAR being considered is an aircraft search RADAR augmented with an electronically scanned antenna both in azimuth and elevation. This implies that the RADAR beam pointing angle can be at a random location as far as the RSG is concerned. Further, the electronic scan implies fixed beam positions while the RADAR is searching for targets.

This radar has two modes of operation...

1. Search is a relatively narrowband process where the RADAR volume is constantly searched for activity. There are several PRFs and several waveforms. The bandwidth of the search waveform is commensurate with the range resolution of the search process, and is approximately 1 MHz. Pulse coding is used as a means of getting power on the target... where a time expanded pulse which is transmitted is compressed on receive back to the

range resolution of the RADAR. In the search mode, the time-bandwidth product of the waveform is approximately 10.

2. The Track mode is what the RADAR uses once a target has been acquired and verified as a bonafide detection. A "track gate" is established and the range resolution is increased 10 fold. As a result, the RADAR has to process just a small portion of the range trace (ie... within the track gate), and the time-bandwidth product of the track waveform is increased to approximately 100.

In Tabular form, the RADAR parameters used have been presented below:

1	Search range:	300	Km	
2	Range resolution in search		150	mtr. (1 uSec)
3	Track gate size		25	uSec
4	Track gate resolution	15	mtr (100 nS)	
5	Azimuth coverage		360	deg. Steerable
6	Elevation coverage		30	deg. Steerable
7	Number of simultaneous targets		100	max
8	Number of targets in beam		20	max
9	Azimuth Beamwidth		2	deg.
10	Elevation Beamwidth	2	deg.	
11	Maximum instrumented range		2000	cells (in search mode)
12	Finest Doppler resolution		1	Hz (0.1 m/sec at 300 MHz RADAR freq)
13	Max unambiguous Doppler		10	Khz
14	Min phenomenologistic freq	0.5	Hz..	clutter motion bandwidth

Some assumptions about clutter:

The precise nature of the clutter model is not important at this stage, consequently, a typical distribution will be planned: Log-normal for amplitude, with a spectral content that can be described using a basis set of overlapping elements, each described, in turn, by a Gaussian spectrum of 0.25 m/sec width.

Figure 1 shows the spectral content of the clutter being described by a basis set of spectral elements:

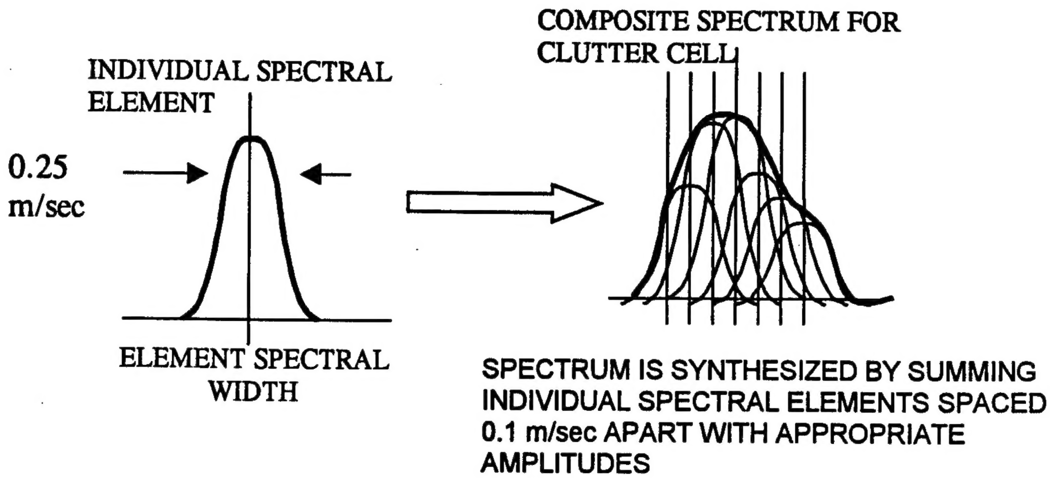


Figure 1 - Clutter spectral synthesis technique

The clutter spectral synthesis consists of a set of lookup tables. At each clutter cell, the Doppler spectrum will consist of a composite which can be constructed from a set of individual spectral elements. Each individual spectral element, has some width associated with it as well as a velocity and is expressed in the form of a table.

At each RADAR pulse interval, the RSG looks up a value in each of these tables and advances the index of the lookup awaiting the next RADAR pulse. An "I" sample and corresponding "Q" sample are extracted and weighted appropriately to create the spectral behavior desired for that cell. The amplitude weight associated with that cell is then used to modulate each component before applying it to the range trace data that will be fed back to the RADAR.

Up to 8 spectral elements are planned for use in the clutter spectral synthesis process. Given the 0.5 Hz physical behavior (row 14 on the RADAR parameter table) that was attempted to be captured, and the 10 KHz max PRF (from row 13 max unambiguous Doppler) that was planned, the table length can be computed as 10KHz / 0.5 Hz = 20K locations. A convenient binary boundary is 32 K locations, each 2 bytes wide.

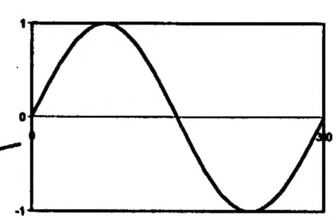
The clutter spectral synthesis tables can be contained in 64KB x 8 basis elements = 512KBytes

Target considerations:

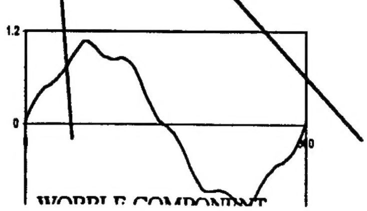
As is the case for clutter, targets have associated with them, amplitudes as well as complex Doppler spectra. Usually, aircraft spectra can be modeled by a main skin return along with a set of spectral lines associated with the propulsion system; whether it is jet engines, propellers or helicopter hub modulation. For the situation where the spectral lines are stationary, the similarity to the clutter synthesis technique can be easily seen. In these situations, just one sinusoidal table is required, and the various spectral lines are synthesized simply by walking through the table at each RADAR pulse interval and summing the values at different indices on the table, each associated with a different spectral line.

In some cases, the spectral lines are not pure, as with helicopter blade flash superimposed on hub rotation. For these situations, special tables exist as seen in Figure 2. Here the behavior associated with helicopter blade flash for example is shown in the form of a perturbed sinusoidal table. Notice that the composite return from this sort of a target will contain components that are purely sinusoidal as well as those that are not, stemming from phenomena discussed above.

- **TARGET DOPPLER FROM TRAJ. GEN**
- **DOPPLER HAS 2 COMPONENTS**
  1 - R-DOT DOPPLER (SKIN RETURN)
  2 - HUB OR (FLASH + HUB) MODULATION



PURE SINUSOID

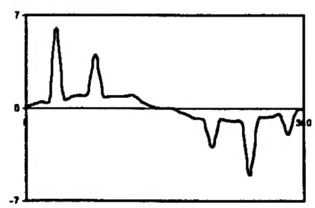


DOPPLER SYNTHESIS TECHNIQUE IS SAME AS FOR CLUTTER.
LOOKUP TABLES AND # OF COMPONENTS MAY BE DIFFERENT

Figure 2 – Complex Doppler synthesis for targets

The finest Doppler resolution will determine the length of the Doppler spectral table for targets. Given the 1 Hz resolution desired (row 12 of the RADAR parameters table) the spectral table length is 10 KHz / 1 Hz = 10 K locations.. conveniently 32Kbytes.

Assuming that all targets can be expressed as some combination of 10 basically different spectra, be they blade flash or other nonlinear behavior, **the memory requirement for target spectral tables is 32KB x 10 = 320 Kbytes.**



ECM considerations

The ECM stimulus will be provided in the same fashion as clutter. For all CW or barrage jammers, the description will lead to the generation of a time sequence. In the case of repeating jammers, there will be responses at specific azimuths placed in the target file, and the jammer responses will be handled as targets.

A lookup table is planned for the ECM as well. Recall that the lookup table approach can be used to synthesize virtually all forms of targets as well as clutter. When appropriately colored noise is used to fill the tables, ECM waveforms are generated. The non RADAR interactive waveforms will be generated in this way, whereas the repeater jammer forms of ECM will be placed as time dependent scenarios in the target file.

The ECM waveforms will be covered in tables that are sized the same as the target tables. **ECM spectral memory is therefore sized at 320 KBytes as well.** This will allow upto 10 separate spectra to be combined into a single jammer location.

A spreadsheet calculator was used to compute the total memory required for the RSG. Remember that the total memory contains the clutter scene as well as the target scene.

	DATABASE MEMORY		RSG MEMORY
	BW	CELL	
AZ	40	20	
EL	28	14	
RNG	150	75	
MAX RNG (CELLS)	2000		
MAX RSG CLTR (CELLS)		4000	2000
MAX AZ COVERAGE (BW)	180		
RSG AZ CLUTTER (BW)		360	180
MAX EL COVERAGE (BW)	50		
RSG EL CLUTTER (BW)		100	22
CLUTTER MEMORY	144 MEGA LOCATIONS		7.92 MEGA LOCATIONS 15.84 MEGABYTES

MAX # OF INSTANTANEOUS TARGETS	100	
DELICIOUS PARAMs	6	
BYTES/PARAM	2	
SAMPLES/SEC	40	
TRACK LENGTH [SECS]	300	
		SPECTRAL MEMORY
TARGET MEMORY	14.4 MEGABYTES	< 2 MB

The DATABASE MEMORY refers to the source of the clutter data. This is the intermediate form of the DFAD and DTED database. A translation program will convert the digital map information into RADAR coordinate space and create an equivalent data file to be placed on disk. The RSG will then read this file and fill the real time memory so the RSG can be run interactively with a RADAR. The finite memory limits the number of targets and the duration of the simulation trial.

The presented spreadsheet computes the size of the memory required by a real time version of the RSG. The components of the RSG database are divided into 3 parts.

1. Clutter Amplitude array. This array contains the amplitudes of the clutter in RADAR resolution cells.

2. Target array. This array contains the critical parameters for targets that will be considered during the current simulation event. For real time interactive simulation, the targets need to reside in memory just to accommodate the speed of the RADAR process. Hence, the complete scenario is pre-computed and placed in memory and the RADAR is run with the specific scene.

3. Spectral array. This array contains spectra for the various processes. The clutter spectra, target spectra that can accommodate all the special considerations such as helicopter blade flash, jet engine modulation (JEM) or artillery shell nutation, and also the tables that will be used to synthesize ECM.

For the non real time situations, such as a desktop simulation, these are not constraints since the data during all portions of the process can be stored on disk.

The benefit of the desktop simulation is that there is practically no limit to the number of simultaneous targets or the duration of the simulation trial. Data is streamed from the disk and applied to the simulation as appropriate. The real time simulation carries more weight in cases where practical RADAR throughput and process complexity are issues to be considered in the overall RADAR algorithm development process.

4.0 Plan for Next Month

Create a complete block diagram. This objective can be broken down into several tasks:

1. The RSG processes will be drafted and interconnected.

2. The interface to each process will be defined.

3. Preliminary metrics for each process block will be explored.

5.0 Anticipated Problems:

None